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Original communication

Pesticide use and related health problems among greenhouse workers in Batinah Coastal Region of Oman

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ABSTRACT

Pesticide practices and the health problems associated with pesticide exposure among 74 greenhouse workers in the Batinah Coastal Region of Oman were investigated. The workers were mostly migrant workers from India (37.8%), Bangladesh (28.4%), Nepal (14.9%), Sri Lanka (8.1%) and Pakistan (5.4%). Majority of the workers (44%) had some primary education, were between 31 and 40 years of age (50%), were married (85.1%) and had been applying pesticides for over 10 years (32.4%). Occupational and phytosanitary practices among the pesticide workers were poor, as most of the workers (59.5%) did not wash their hands after pesticide application, many (43.2%) did not shower and some (20.3%) did not change their clothes. Their methods of handling of partly used pesticides were questionable, with 81.1% storing them in other rooms in the house and 14.9% storing them in their bedrooms. Personal protective equipment (PPE) such as nose mask, overall and eye goggles were hardly used during pesticide application. Some of the reported health symptoms due to pesticide exposure were skin irritation (70.3%), burning sensation (39.2%), headache (33.8%), vomiting (29.7%) and salivation (21.6%). It was suggested that a provision be included in the Pesticide Laws of Oman that makes it mandatory for greenhouse owners to provide their workers with PPE. Also, regular training programs should be organized for the greenhouse pesticide workers to improve their ability to handle hazardous chemicals.

1. Introduction

The Batinah Coastal Region of Oman accounts for about 60 percent of all the country's agricultural production and has witnessed vigorous development in recent years.[1]

Although open field farming is the most widely used, interest in the use of greenhouses, especially for the production of horticultural crops is increasing. Also on the increase is the use of pesticides to control agricultural pests which have become a menace to greenhouse crops. According to FAO report, the quantity of pesticides imported to Oman has increased more than ten folds in the recent past.[2]

Greenhouse workers are directly exposed to pesticide poisoning when a fogging sprayer is used, as this leaves a fine mist on the pesticide applicator. Indirect exposure may occur as the greenhouse worker walks up and down the confined rows of the greenhouse and comes in contact with plants that have been treated with pesticides. The dermal route is generally the most important route of entry for occupational pesticide exposure.[3,4] However, inhalation exposure may be important. Pesticides contain several additives such as solvents, therefore inadvertent ingestion may be relevant in certain cases.[5] The occupational exposure to these chemicals and the subsequent adverse health effects are not limited to the agricultural workers alone but extend to members of the farming families, as whole families including children and the elderly are often involved in working in the greenhouse.[6] In Oman, because of the extensive use of pesticides to control agricultural pests and in the absence of active pesticide legislation, applied pesticides have had adverse side effects on human health and the environment.[2]

Most of the research on pesticide exposure in the developing countries has focused primarily on open field workers, therefore there is a paucity of information concerning greenhouse workers. There is a need to correct this information imbalance, especially since there has been an upsurge in the ownership of greenhouses in the Sultanate of Oman in the recent past, resulting in an increased use of pesticides. Also, it is generally recognized that conditions in the greenhouse are designed to optimize the environment for plant growth, rather than for the worker's health.[5] Therefore, thereis also a need for information on pesticide related health problems amonggreenhouse pesticide applicators. The present study was

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undertaken among greenhouse workers in the Batinah Coast Region of Oman, majority of whom are migrant workers.

2. Material and methods

Systematic sampling procedure was utilized for this study because there were no official list of greenhouses in the Sultanate of Oman from which a sample could be drawn. Thus, on the first day of questionnaire administration, the 3rd greenhouse and thereafter every 5th greenhouse was selected to be included in the sample. During a preliminary survey made between July and October 2008, thirty greenhouses were randomly selected from North, Central and South Batinah, respectively making a total of 90 green houses. A sample of 74 workers voluntarily agreed to participate in the study. Based on the data collected during the preliminary study, a questionnaire was designed in line with the World Health Organization Field Surveys of Exposure to Pesticide Standard Protocol.[8] Subsequently, the study was approved by the Texas Southern University Committee for Protection of Human Subjects on November 24, 2008 and copies of the questionnaire were administered to the workers between December 3, 2008 and January 31, 2009. Face to face interviews/administration of questionnaire was used because, through informal discussions, it was noted that most of the workers had little or no formal education, and those who had some education were not familiar with the terminologies used in the questionnaire. At the onset of each interview, the objectives of the study were explained to the subjects and they were assured of the confidentiality of their responses. They were also told that they had the option to answer all, some or none of the questions.

The data collected were coded and analyzed using the Statistical Package for the Social Sciences.[9]

3. Results

The most frequently used pesticides by greenhouse workers in Oman are shown in Table 1. These include Carbosulfan, Carbaryl, Malathion, Methyl bromide and Endosulfan, applied by 94.6, 93.2, 92, 54.1 and 78.4.9% of the workers, respectively. Carbosulfan and Carbaryl are classified as carbamates, while Malathion is classified as an organophosphate. Methyl bromide and Endosulfan are classified as organochlorine.

Majority of the workers were between 31 an 40 years of age, while only a very small percentage (2.6%) were above 60 years (Table 2). Workers with some primary school education were the most in number (59.6%) compared to those who had completed secondary school which accounted for only 1.4% of the work force. Indian immigrant workers were in majority (37.8%), followed by immigrants from Bangladesh (28.4%) and Nepal (14.9%). Native Omani workers constituted only 5.4% of the total pesticide applicators. Although majority (85.1%) of the workers were married, most of them left their families in their home countries. Workers with over 10 years experience in pesticide usage were in the majority (32.4%), followed by those with 5–7 years of experience (Table 3). Only a small number (8.1%) had pesticide application experience of one year or less. In terms of frequency of pesticide

Table 1
Pesticides used by greenhouse workers in Oman.

Pesticides	Chemical Class	Workers *n (%)*
Parathion	Organophosphate	40 (54.1)
Monocrotophos	Organophosphate	16 (21.6)
Chlorpyrifos	Organophosphate	13 (17.6)
Dimethoate	Organophosphate	27 (36.5)
Methyl parathion	Organophosphate	17 (23.0)
Diazinon	Organophosphate	55 (74.3)
Malathion	Organophosphate	68 (92.0)
Dichlorvos	Organophosphate	58 (78.4)
Lindane	Organochlorine	34 (46.0)
Methyl bromide	Organochlorine	40 (54.1)
DDT	Organochlorine	42 (56.8)
Carbosulfan	Carbamates	70 (94.6)
Carbaryl	Carbamates	69 (93.2)
Proxipur	Carbamates	32 (43.2)
Deltamethrin	Pyrethroid	12 (16.2)
Cypermethrin	Pyrethroid	8 (10.8)
Metolachlor	Chloroacetanilide	10 (13.5)

Table 2
Socio-demographic characteristics of greenhouse workers.

	Greenhouse workers $n = 74$ (%)
Age groups	
20 years or less	4(5.4)
21–30	9 (16.2)
31–40	37 (50)
41–50	9 (12.2)
51–60	10 (13.5)
more than 60	2 (2.7)
Education	
Did not attend school	8 (10.8)
Some primary school	44 (59.6)
Completed primary school	17 (23)
Some secondary school	4 (5. 4)
Completed secondary school	1 (1.4)
Nationality	
Omani	4 (5.4)
Indian	28 (37.8)
Nepalese	11 (14.9)
Pakistani	4 (5.4)
Sri Lankan	6 (8.1)
Marital status	
Married	63 (85.14)
Single	11 (14.86)

Table 3
Work habits of greenhouse workers in Oman.

How long have you been spraying pesticides?	
Number of years	Workers *n* (%)
1 year or less	6(8.1)
2–4 years	14(18.9)
5–7 years	22(29.7)
8–10 years	8(10.8)
More than 10 years	24(32.4)
Frequency of pesticide application	
Frequency	
Twice a week	51 (68.9)
Once a week	13 (17.6)
Twice a month	9 (12.2)
Once a month	1(1.4)
How soon after spraying do you re-enter your greenhouse?	
Number of hours	
1 h or less	32 (43.2)
2–4 h	22 (29.7)
5–7 h	6 (8.1)
8–10 h	10 (13.5)
More than 10 h	4 (5.4)
Average time spent daily in the greenhouse	
Average time	
1–3 h	10 (13.5)
4–6 h	18 (24.3)
7–9 h	35 (47.3)
More than 9 h	11 (14.9)
Personal habits during pesticide application	
Hygiene habits	Sometimes
Smoking	14 (18.9)
Drinking water	7 (9.5)
Chewing gum	16 (21.6)
None of the above	37(50.0)

application, twice a week was the most common (69.9%), followed by once a week (17.6%) and twice a month (12.2%). Most of the workers (43.2%) re-entered the greenhouse 1 h or less after applying pesticides, while only a small percentage of the workers (5.4%) claimed that they re-entered the greenhouse more than 10 h after pesticide application. Overall, 86.5% of the workers spent more than 4 h daily in the confined environment of the greenhouse, while 13.5% spent between 1 and 3 h. The hygiene habits of the workers during pesticide application were questionable, as up to 21.6% of the subjects indicated that they chewed gum during the spraying process, while 9.5% indicated that they drank water, 18.9% of the workers smoked cigarette.

The workers' post-pesticide application practices are shown in Table 4. Up to 43.2% showered; 27% washed their equipment; 59.9% washed their hands and 20.3% changed their clothes after applying pesticides. Therefore, 79.7% of the respondents did not change their clothes, while 56.8% did not shower after applying pesticides. With respect to storage of partly used pesticides, 14.9% of the workers indicated that they stored their partly used pesticides in their bedrooms; 81.1% stored them in other rooms in the house; 2.7% stored them in the store room, while 9.5% indicated that they stored partly used pesticides in locked cupboards.

Different disposal methods of empty pesticide containers were used by the workers. About 10.8% of the respondents indicated that they used the empty pesticides containers to store food, while 17.6% reported that they buried the empty pesticides containers in the ground. Only 2.7% reported that they threw the empty pesticides containers into the open fields. A high percentage (71.6%) of the respondents reported that they threw them into the garbage dump.

The personal protective equipments (PPE) available to the workers were eye goggles, long pants, gloves, boots, overall and nose mask (Table 5). The percentages of workers who never used the PPE were 62.2% (eye goggles), 35.1% (long pants), 45.9% (gloves), 51.4% (boots), 81.1% (overall), and 81.1% (nose mask). Some of them sometimes used some of the PPE as follows: eye goggles (23%), long pants (6.8%), gloves (35.1%), boots (14.9%), overall (6.8%), nose mask (6.8%). The percentages of the workers who indicated that they always used the PPE were 14.9% (eye goggles), 58.1% (long pants), 18.9% (gloves), 33.8% (boots), 12.2% (overall), and 12.2% (nose mask). Therefore, more than 85% of the workers never or sometimes used eye goggles, overalls, or nose mask.

Asked why PPE were selectively used or not used at all, 16.2% of the respondents reported that gloves were uncomfortable; 32.4% indicated that they were not necessary, while 41.9% reported that they were not supplied by their employers (Table 6). Regarding the reason for not wearing eye goggles, 24.3% of the respondents reported that eye goggles were uncomfortable; 28.4% indicated that they were not necessary, while 40.5% of the subjects indicated that they were not supplied by their employers. As to why boots were not worn, 21.6% reported that they were uncomfortable, 28.4% indicated that they were not necessary and 40.5% of the subjects indicated that they were not supplied by their employers. Nose masks were not used because they were either uncomfortable (35.1%), not necessary (16.2%) or not supplied by their employers (41.9%).

The health symptoms reportedly experienced by the workers while applying pesticides are shown in Table 7. Skin irritation was mentioned by 70.3% of the respondents; 2.7% mentioned dizziness, while chest pain was reported by only 4.1% of the greenhouse workers. Headache was experienced by 33.8% of the workers, while salivation and vomiting were reported by 21.6% and 29.7% of the workers, respectively. Other symptoms reportedly experienced by the subjects were burning sensation (39.2%) and weakness (5.4%).

Wearing of long pants was negatively correlated with the incidence of skin irritation ($R = -0.374^{**}$) and burning sensation ($R = 0.489^{**}$), suggesting that this PPE was associated with a reduced incidence of skin irritation and burning sensation (Table 8). Similarly, wearing of nose mask was negatively correlated with the incidence of headache and vomiting, R values being -0.348^{**} and -0.401^{**}, respectively. These results indicate a relationship between nose mask usage and a reduced incidence of headache and vomiting. Wearing of eye goggles ameliorated headache incidence, the correlation ($R = -0.418^{**}$) being negative and highly significant (Table 9).

Re-entry interval was negatively correlated with burning sensation on face/eyes ($R = -0.262^{*}$); weakness ($R = -0.300^{**}$); breathlessness ($R = -0.265^{*}$); cough ($R = -0.391^{**}$). A negative correlation between re-entry interval and the reported symptoms suggests that the longer the greenhouse worker stays away from the greenhouse after pesticides application, the lower the number of the health symptoms reportedly experienced.

Table 4
Post-pesticide application action and disposal methods.

Hygiene habits	
Practices	Workers *n* (%)
Shower	32 (43.2)
Wash equipments	20 (27)
Wash hands	44 (59.5)
Change clothes	15 (20.3)
Handling of partly-used pesticides	
Location	
In their bedrooms	11 (14.9)
Other rooms in the house	60 (81.1)
the store room	2 (2.7)
In a locked cupboard	7 (9.5)
Disposal methods of empty pesticide containers	
Disposal practices	
To store food	8 (10.8)
Bury	13 (17.6)
Throw into the open fields	2 (2.7)
Throw into the garbage	53 (71.6)
Burn	10 (13.5)

Table 5
Use of personal protective equipments (PPE).

	Workers *n* (%)		
PPE	Never	Sometimes	Always
Eye goggles	46 (62.2)	17 (23)	11 (14.9)
Long pants	26 (35.1)	5 (6.8)	43 (58.1)
Gloves	34 (45.9)	26 (35.1)	14 (18.9)
Boots	28 (51.4)	11 (14.9)	25 (33.8)
Overall	60 (81.1)	5 (6.8)	9 (12.2)
Nose mask	60 (81.1)	5 (6.8)	9 (12.2)

4. Discussion

The study noted that some of the pesticides which fall under Class 1a and which have either been banned,[10] or highly restricted in the industrialized nations are still being used in greenhouses in

Table 6
Reason for not using personal protective equipments (PPE).

	Worker *n* (%)			
	Uncomfortable	Expensive	Not Necessary	Not supplied
Gloves	12 (16.2)	1 (1.4)	24 (32.4)	31 (41.9)
Eye goggles	18 (24.3)	0 (0)	21 (28.4)	30 (40.5)
Boots	16 (21.6)	1 (1.4)	21 (28.4)	30 (40.5)
Overall	25 (33.8)	2 (2.7)	15 (20.3)	30 (40.5)
Nose mask	26 (35.1)	3 (4.1)	12 (16.2)	31 (41.9)
Hats	17 (23.0)	2 (2.7)	23 (31.1)	29 (39.2)

Table 7
Reported symptoms of exposure to pesticides.

Symptoms	Workers *n* (%)
Skin Irritation	52 (70.3)
Dizziness	2 (2.7)
Chest pain	3 (4.1)
Headache	25 (33.8)
Salivation	16 (21.6)
Vomiting	22 (29.7)
Burning sensation	29 (39.2)
Weakness	4 (5.4)
Blurred vision	13 (17.6)
Breathlessness	6 (8.1)
Cough	22(29.7)

the Batinah region of Oman. For example, 40 greenhouse workers claimed to have used parathion, or methyl bromide. Methyl bromide has been shown to deplete the stratospheric ozone layer,[11] therefore, according to the Montreal Protocol attempts are being made to curtail its use as a fumigant.[7] In Turkey four of the five mostly used pesticides, Methamodophos, Dichlorvos, Omethoate and Phthalilmibe, belong to the "very poisonous" group.[12] We suggest that regular training programs be organized for the greenhouse workers to improve their ability to handle hazardous chemicals. Generally, pesticide safety is higher when the level of education among the applicators is higher.[2]

One of the objectives of this study was to investigate the extent of the use of migrant workers in agriculture in the Sultanate of Oman. Our results show that almost 95% of the green house workers were migrant workers, that is, non-Omanis, and that they were mainly ethnic Asians mostly from India and Bangladesh. In a comparative study of migrant workers in the United Arab Emirates (UAE), it wasnoted that majority of the farmers were ethnic Asians mostly from India.[12] Regarding their level of education, our results show that more than 90% of the greenhouse respondents did not go beyond primary education. These observations are similar to those made earlier.[12,13] The ominous effects of low level of education of pesticide workers in developing countries as noted in our study and by other researchers in other countries are many and varied. An issue that seems to be directly related is whether or not they can read and understand instruction labels including expiration dates on pesticide containers. More than 80% of the greenhouse workers "never" or only "sometimes" read instruction labels on pesticide container. The same percentage of workers "never" or only "sometimes" checked the expiration dates on pesticide containers. The inability to read and understand pesticide container labels often leads to misuse or overuse of pesticides.

The frequency of pesticide application and the average number of hours spent in the greenhouse provide information about the extent of exposure to pesticides. Most of the workers (69.9%) applied pesticides twice a week and a majority of them spent more than 4 h daily in the confines of their greenhouses. Obviously, these practices increased the workers' exposure to pesticides and this exposure was also aggravated by the early re-entry into sprayed greenhouses. In our study, most of the workers (43.2%) re-entered the greenhouse 1 h or less after applying pesticides. Generally, the longer the re-entry interval, the less the risk of exposure and intoxication from pesticides in the environment which remains as residue on plants and/or soil.[2,14]

Table 8
Relationship between PPE usage and reported symptoms.

PPE	R
Long pants vs skin irritation	−0.374**
Long pants vs burning sensation	−0.489**
Nose mask vs headache	−0.348**
Nose mask vs vomiting	0.401**
Eye goggles vs headache	−0.418**
Wearing of boots vs headache	−0.296*
Wearing of boots vs weakness	−0.310**
Overall vs vomiting	−0.401**
Overall vs headache	−0.348**

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

Table 9
Correlation of re-entry interval and reported symptoms.

Re-entry interval	Reported symptoms	R
	Burning sensation	−0.262*
	Weakness	−0.300**
	Breathlessness	−0.265*
	Cough	−0.391**

*,** Significant at 0.05 and 0.01 probability levels, respectively.

The use of effective protective clothing such as gloves and nose masks reduces pesticides contamination.[15] However, the lack of use of effective protective clothing by farm workers in developing countries has been noted by several past researchers.[16–20] This probably has to do with their low level of education and the erroneous idea that long experience in pesticide application meant that they would be careful during the spraying process and therefore PPE were not needed. Previous report has shown that the perception that PPE were useful was associated with at least high school education.[21] In Ghana, more than one quarter of the respondent irrigation workers "never" wore gloves when mixing or applying pesticides.[14] The results of our study show that more than 80% of the greenhouse workers "never" or only "sometimes" used PPE such as eye goggles, gloves, overalls, and nose masks. Therefore, most of the pesticide workers were unduly exposed to agricultural pesticide contamination because of the non-use of protective clothing. In Ethiopia, some of the sprayers were reluctant to wear gloves in hot weather.[22] Such unsafe practice was also recorded among pesticide sprayers in Mississippi.[23] In our study, the most common excuses for not using PPE were that they were not supplied (40%) or were uncomfortable (26%). In order to reduce exposure, we suggest that a provision be included in the Pesticide Laws of Oman that makes it mandatory for employers to provide their workers with PPE. Apart from dermal exposure, other exposure routes are oral, respiratory and ocular.[25] Dermal exposure can occur directly from the source of exposure; transfer type of exposure is due to contact with contaminated surfaces; and deposition is exposure through skin on contact with small particles of pesticides present in the air compartment.[24] Therefore, greenhouse workers who do not use PPE probably run considerable health risks due to exposure. An earlier report has shown that whole body protection prevents skin absorption and reduces secondary contamination from residues on plant leaves, benches and equipment.[26]

Failure to wash hands and not showering after pesticide application are very poor hygiene habits practiced by many of the pesticide workers. Additionally, as high as 21.6% of the subjects indicated that they chewed gum during the spraying process, and 18.9% of them smoked cigarette. Obviously, smoking at work could constitute a potential source of ingestion during the handling of cigarettes with contaminated fingers.[14] There has, in fact, been documentation of trace amounts of chemical ingestion by pesticide workers.[27] Most of the workers in our study had over 10 years experience in pesticide usage, therefore it was surprising that they were not overly worried about the harmful effects of such poor hygiene practices. Additionally, 14.9% of the workers indicated that they stored their partly used pesticides in their bedrooms; 81.1%

stored them in other rooms in the house and about 10.8% of the respondents used the empty pesticides containers to store food. The cumulative effects of such exposures over long periods of time obviously constitutes a significant risk to workers. Also, when empty plastic pesticide containers are burned, harmful quantities of dioxins, a group of highly toxic and carcinogenic chemicals are emitted.[28] Some of the workers claimed that they disposed of empty containers by burning them and over a long period, this practice may constitute a health hazard.

Several health symptoms associated with exposure to pesticides by greenhouse workers have been reported.[1,12,13,29,30] A prolonged exposure to pesticides can lead to asthma, hypertension, nerve damage, liver disease, nervousness, irritability, and impaired concentration.[13] Our study shows that pesticide exposure by greenhouse workers in Oman was related to several health symptoms, notably skin irritation, headache, salivation, burning sensation and vomiting. In the Gaza Strip, burning sensation in eye/face was the most commonly reported symptom among pesticide workers,[20] while in the UAE a high incidence of respiratory symptoms was observed among pesticide applicators compared to non-farm workers.[13] In Ethiopia, pesticide poisoning among farm residents from organophosphate compounds included anxiety and depression.[24] Obviously, reported health symptoms vary widely among greenhouse workers in different countries. Additionally, there is a large number of pesticide formulations in use, inherently resulting in exposure groups with heterogeneous chemical composition.[31] However, there is no doubt that the use of PPE such as nose mask, eye goggles, overall and boots may reduce pesticide exposure and the incidence of acute and chronic poisonings among these workers. In our study, wearing of nose mask, for instance was negatively correlated with vomiting, suggesting that the incidence of vomiting could be reduced by wearing nose mask. Similarly, the use of long pants and eye goggles may reduce the incidents of skin irritation and headache, respectively. Although these may not necessarily be direct "cause and effect" relationships, they do suggest that the use of PPE during pesticide application can greatly reduce the incidence of exposure and that the corollary is true.

5. Conclusion

Farm workers and the general population are exposed to hazardous pesticides with limited understanding and awareness of the short and long term implications of these exposures. Our study therefore highlights the need for the government of Oman, through the appropriate agencies, to develop policies that will provide risk communication tools that are appropriate for protecting greenhouse pesticide workers. Risk communication strategies such as pesticide labels and cautionary symbols are useful in providing information to farmers, traders and the general population about the hazards of exposure to chemicals. Taking into consideration that a high percentage of the subjects in the current study were migrant workers, government should liaise with agro-chemical manufacturing companies to ensure that pesticides labels are not only written in English and Arabic but also in the native dialect of the major group of migrant workers. A follow up study on the cholinesterase enzyme concentration in the exposed workers may provide information on the long time effects of pesticides on these workers.

Ethical approval

This study was approved by the Texas Southern University Committee for the Protection of Human Subjects on November 24, 2008.

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Conflict of interest

None.

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